**WHAT IS CLAIMED IS:**

1. A method of forming a substrate optical waveguide having a propagation axis along which light is conveyed, a cladding layer, and a core element, the core element having an elongated dimension collinear with the waveguide's propagation axis and a transverse cross-section transverse to the elongated dimension, the method comprising the steps of:

(a) forming a lower cladding layer of photosensitive cladding material;

(b) exposing the cladding layer to actinic radiation through a first gray-scale mask;

(c) developing the exposed pattern to form a groove located in the lower cladding layer and having three-dimensional features;

(d) forming a core layer of photosensitive core material over the groove and the remaining portions of the lower cladding layer;

(e) exposing the core layer to actinic radiation through a second gray-scale mask; and

(f) developing the exposed pattern to form an element of core material located over the groove and having three-dimensional features.

2. The method of Claim 1 wherein the photosensitive cladding material is positive type.

3. The method of Claim 1 wherein the photosensitive core material is positive type.

4. The method of Claim 1 further comprising the step of forming an upper cladding layer over the exposed portions of the core element and lower cladding layer.

5. The method of Claim 1 further comprising, after step (c) and prior to step (d), the step of at least partially curing the lower cladding layer.

6. The method of Claim 1 further comprising, after step (c) and prior to step (d), the step of reducing the sensitivity of the lower cladding layer to the actinic radiation used in step (e).

7. The method of Claim 1 wherein the element of core material has a circular cross-section in a plane transverse to the waveguide's propagation axis.

8. The method of Claim 1 wherein the element of core material has an oval-shaped cross-section in a plane transverse to the waveguide's propagation axis.

9. The method of Claim 1 wherein the element of core material has top and bottom surface portions which are curved.

10. The method of claim 1 wherein each of the cladding and core materials comprises a common base photosensitive polymer material, and wherein one of the cladding and core materials comprises a minor addition of a different polymer material.

11. A method of forming a substrate optical waveguide having a propagation axis along which light is conveyed, a cladding layer, and a core element, the core element having an elongated dimension collinear with the waveguide's propagation axis and a transverse cross-section transverse to the elongated dimension, the method comprising the steps of:

(a) forming a cladding layer of a photosensitive cladding material on a substrate, the solubility of the cladding material in a developer being a function of exposure dosage to actinic radiation;

(b) pattern exposing the cladding layer to actinic radiation through a first gray-scale mask, the first gray-scale mask comprising a first area for defining a first segment of the core element, the first area having a length oriented to the propagation axis of the waveguide and a width for initially defining the transverse cross-section of the core element in the first segment, the first area of the first gray-scale mask having a gradation of opacity along its width;

(c) thereafter exposing the cladding layer to a developer to form a groove in the layer of photosensitive cladding material, the groove having a first segment with a length disposed along the waveguide's propagation axis and a major curved surface which is curved in a direction transverse to the length of the grooves first segment;

(d) forming a core layer of a photosensitive core material over the groove and the cladding layer, the solubility of the core material in a developer being a function of exposure dosage to actinic radiation;

(e) pattern exposing the core layer to actinic radiation through a second gray-scale mask, the second gray-scale mask comprising a first area for further defining the first segment of the waveguide's core element, the first area having a length oriented to the propagation axis of the waveguide and a width for further defining the transverse cross-section of the core element in the first segment, the first area of the second gray-scale mask having a gradation of opacity in the direction of its width; and

(f) thereafter exposing the core layer to a developer to form the first segment of the waveguide's core element.

12. The method of Claim 11, wherein the first gray-scale mask of step (b) further comprises a second area for defining a second segment of the core element, the second area having a length oriented to the propagation axis of the waveguide and a width for initially defining the transverse cross-section of the second segment of the core element, the second area of the first gray-scale mask having a first gradation of opacity along its width and a second gradation of opacity along its length;

wherein step (c) of exposing the cladding layer to a developer further forms the groove with a second segment with a length disposed along the waveguide's propagation axis and a major surface which is curved in a direction transverse to the length of the groove's second segment, the groove's second segment having a gradation in its width and a gradation in its depth;

wherein step (d) of forming the core layer further forms the photosensitive core material over the second segment of the groove;

wherein the second gray-scale mask of step (e) further comprises a second area for further defining the second segment of the waveguide's core element, the second area

having a length oriented to the propagation axis of the waveguide and a width for further defining the transverse cross-section of the core element in the second segment, the second area of the second gray-scale mask having a first gradation of opacity in the direction of its width and a second gradation of opacity along its length; and

wherein step (f) of exposing the core layer to a developer further forms the second segment of the waveguide's core element.

13. The method of Claim 11, wherein the first gray-scale mask of step (b) further comprises a second area for defining a second segment of the core element, the second area having a length oriented to the propagation axis of the waveguide and a width for initially defining the transverse cross-section of the second segment of the core element, the second area of the first gray-scale mask having a first portion with a first gradation of opacity along its width and a second portion with a radial gradation of opacity about a point;

wherein step (c) of exposing the cladding layer to a developer further forms the groove with a second segment with a length disposed along the waveguide's propagation axis and a major surface which is curved in a direction transverse to the length of the groove's second segment, the major surface of the groove's second segment further having a portion which is curved in the direction of the length of the groove's second segment;

wherein step (d) of forming the core layer further forms the photosensitive core material over the second segment of the groove;

wherein the second gray-scale mask of step (e) further comprises a second area for further defining the second segment of the waveguide's core element, the second area having a length oriented to the propagation axis of the waveguide and a width for further defining the transverse cross-section of the core element in the second segment, the second area of the second gray-scale mask further having a first portion with a gradation of opacity in the direction of the second area's width and a second portion having a circle or oval of constant opacity; and

wherein step (f) of exposing the core layer to a developer further forms the second segment of the waveguide's core element.

the groove's second segment

14. The method of Claim 13 further comprising, between the performance of steps (c) and (d), the step of forming a layer of reflective metal on the bottom surface of the groove's second segment.

15. The method of Claim 11 wherein the photosensitive cladding material is positive type.

16. The method of Claim 11 wherein the photosensitive core material is positive type.

17. The method of Claim 11 further comprising the step of forming an upper cladding layer over the exposed portions of the core element and lower cladding layer.

18. The method of Claim 11 further comprising, after step (c) and prior to step (d), the step of at least partially curing the lower cladding layer.

19. The method of Claim 11 further comprising, after step (c) and prior to step (d), the step of reducing the sensitivity of the lower cladding layer to the actinic radiation used in step (e).

20. The method of Claim 11 wherein the element of core material has a circular cross-section in a plane transverse to the waveguide's propagation axis.

21. The method of Claim 11 wherein the element of core material has a circular cross-section in a plane transverse to the waveguide's propagation axis.

22. The method of Claim 11 wherein the element of core material has top and bottom surface portions which are curved.

23. The method of Claim 11 wherein each of the cladding and core materials comprises a common base photosensitive polymer material, and wherein one of the cladding and core materials comprises a minor addition of a different polymer material.

24. A substrate optical waveguide having a propagation axis along which light is conveyed, said substrate optical waveguide comprising:

a lower cladding layer having a top surface, a bottom surface, a first refractive index for light having a first free-space wavelength, and a groove formed in the top surface, the groove having a first segment with a major curved surface and a lowermost depth that lies between the top and bottom surfaces of the lower cladding layer, said lower cladding layer being formed from a photosensitive material such that the lower cladding layer comprises an amount of a photo-active compound and/or an amount of a decomposed photo-active compound;

a core element having an elongated dimension collinear with the waveguide's propagation axis and a transverse cross-section transverse to the elongated dimension, said core element having a second refractive index for light having the first free-space wavelength, the second refractive index being different from the first refractive index, the core element further having a first core segment formed in and over the first segment of the groove and having a major top curved surface and a major bottom curved surface, said core element being formed from a photosensitive material such that the core element comprises an amount of a photo-active compound and/or an amount of a decomposed photo-active compound; and

an upper cladding layer formed over at least one of the exposed portions of said lower cladding layer and at least one of the exposed portions of said core element.

25. The substrate optical waveguide of Claim 24 wherein the core element has a circular cross-section in a plane transverse to the waveguide's propagation axis.

26. The substrate optical waveguide of Claim 24 wherein the groove of the lower cladding layer further has a second segment adjacent to the first segment, the second segment of the groove having a major curved surface and a lowermost depth that lies

between the top and bottom surfaces of the lower cladding layer, the groove's second segment having a gradation in its width and a gradation in its depth; and

wherein the core element further has a second segment formed in and over the second segment of the groove and having a major top curved surface and a major bottom curved surface, the bottom major surface of the core element's second segment having a gradation in its width and a gradation in its depth, the top major surface of the core element's second segment having a gradation in its width and a gradation in its height.

27. The substrate optical waveguide of Claim 24 wherein the groove of the lower cladding layer further has a second segment adjacent to the first segment, the second segment of the groove having a major curved surface and a lowermost depth that lies between the top and bottom surfaces of the lower cladding layer, the groove's second segment having a gradation in its width and a gradation in its depth in a form of the lower portion of an elbow-bend; and

wherein the core element further has a second segment formed in and over the second segment of the groove and having the form of an elbow-bend.

28. The substrate optical waveguide of Claim 24 wherein the groove of the lower cladding layer further has a second segment adjacent to the first segment, the second segment of the groove having a major curved surface and a lowermost depth that lies between the top and bottom surfaces of the lower cladding layer, the groove's second segment having a gradation in its width and a gradation in its depth in a form of the lower portion of an elbow-bend;

a layer of metal formed on the surface of the elbo-bend; and

wherein the core element further has a second segment formed in and over the second segment of the groove and the layer of metal, the second segment of the core element having the form of an elbow-bend.

29. A substrate optical waveguide having a propagation axis along which light is conveyed, said substrate optical waveguide comprising:

a lower cladding layer having a top surface, a bottom surface, a first refractive index for light having a first free-space wavelength, and a groove formed in the top surface, the groove having a first segment with a major curved surface and a lowermost depth that lies between the top and bottom surfaces of the lower cladding layer, and a second segment adjacent to the first segment, the second segment of the groove having a major curved surface and a lowermost depth that lies between the top and bottom surfaces of the lower cladding layer, the groove's second segment having a gradation in its width and a gradation in its depth in a form of the lower portion of an elbow-bend;

a core element having an elongated dimension collinear with the waveguide's propagation axis and a transverse cross-section transverse to the elongated dimension, said core element having a second refractive index for light having the first free-space wavelength, the second refractive index being different from the first refractive index, the core element further having a first core segment and a second core segment adjacent to the first core segment, the first core segment being formed in and over the first segment of the groove and having a major top curved surface and a major bottom curved surface, the second core segment being formed in and over the second segment of the groove and having the form of an elbow-bend; and

an upper cladding layer formed over at least one of the exposed portions of said lower cladding layer and at least one of the exposed portions of said core element.

30. The substrate optical waveguide of Claim 29 wherein the first core segment has a circular cross-section in a plane transverse to the waveguide's propagation axis.